Quantum Dot Biosensor for Detection of Troponin I Using a Liquid-Core Waveguide Platform

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Introduction

- Human cardiac Troponin I (TnI) is a subunit of the cardiac Troponin complex
- Upon cardiac injury, TnI is released into the bloodstream
- Accurate, sensitive, and expeditious detection of TnI is important for diagnosis of myocardial infarction
- Proposed biosensor must be capable of rapid, sensitive, and selective TnI detection

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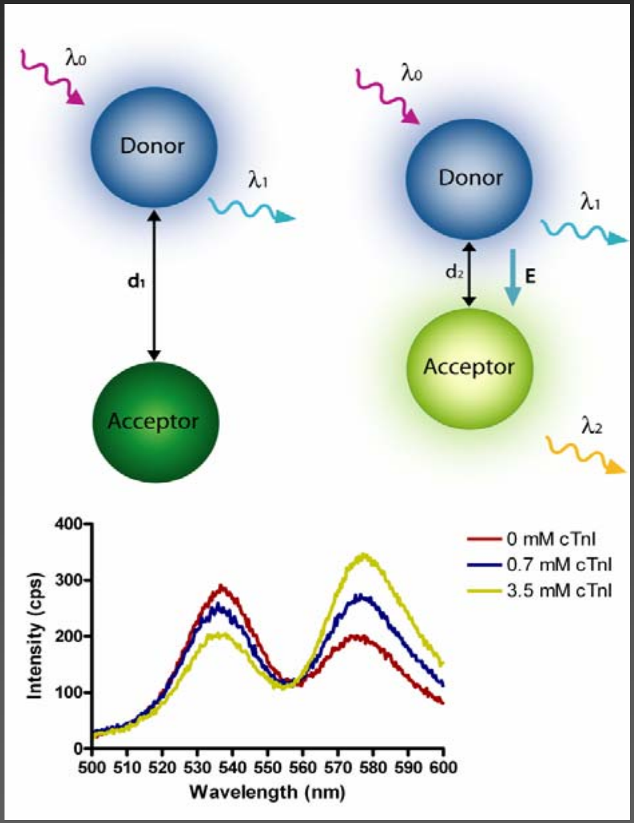
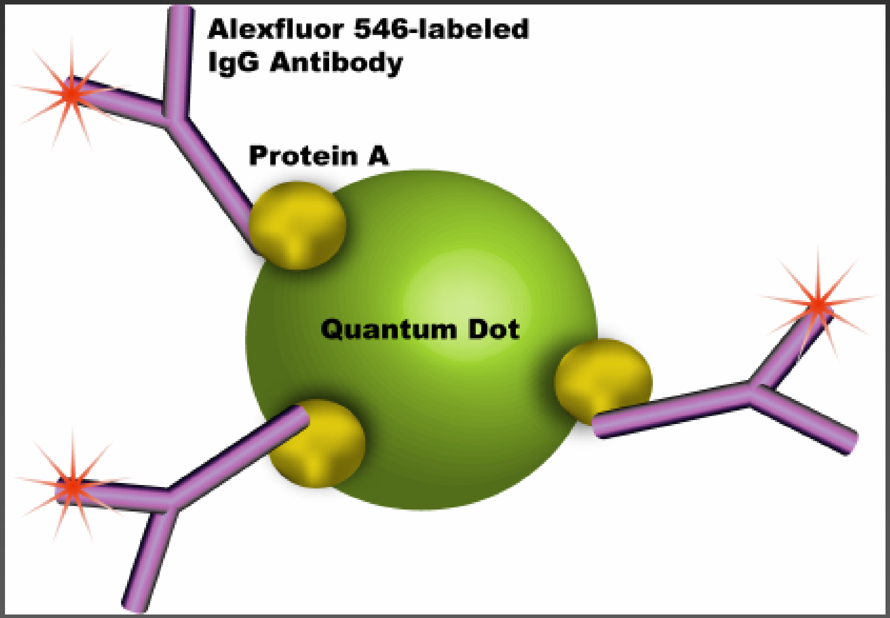
Fluorescence Resonance Energy Transfer

- Nonradiative energy transfer between donor and acceptor fluorescent species
- Requires species to be in close proximity and spectral overlap in donor emission and acceptor absorbance
- Degree of energy transfer is highly sensitive to distance between fluorescent molecules



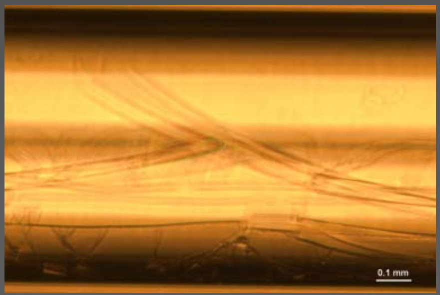
Biosensor Architecture

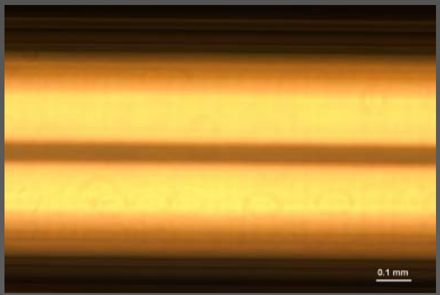


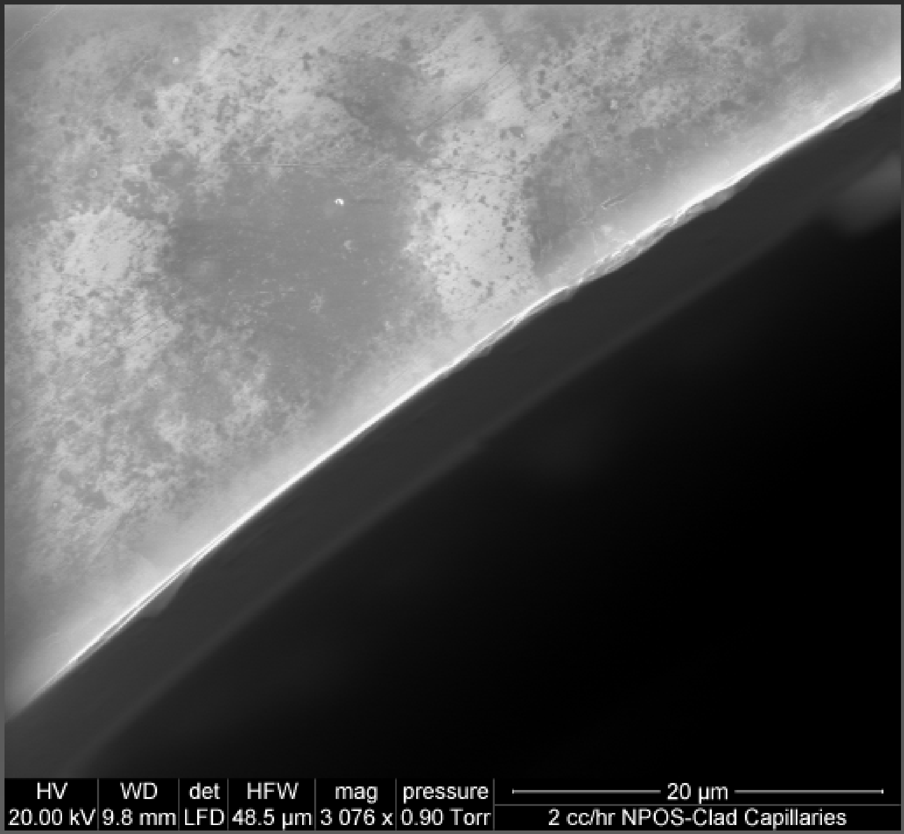
- Quantum dot FRET donor & molecular scaffold
- Bound to acceptor-labeled TnI antibody
- Upon antibody-antigen binding, conformation change in antibody occurs
- Resulting change in distance between donor and acceptor is detected by change in FRET efficiency

Liquid-Core Waveguide Platform

- Glass capillaries lined with a nanoporous organosilicate layer (refractive index ~ 1.22)
- Layers vary in thickness from 2.52 to 4.41 µm based on flow rate







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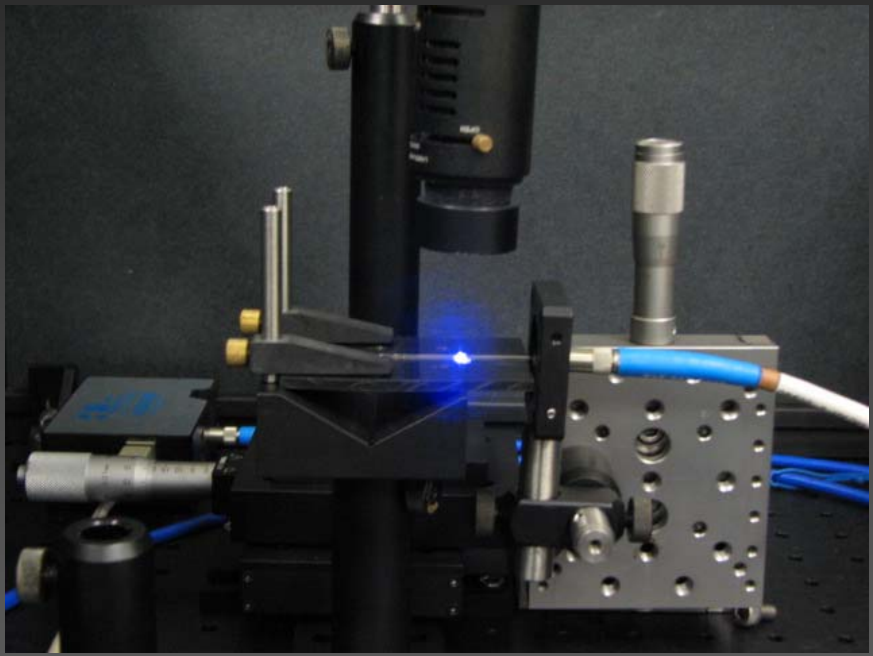
Fluorescence Measurements

- Biosensor solutions prepared and combined with analyte solution
- Injected into liquid-core waveguide
- Illuminated at 405 nm
- Guided fluorescence coupled into optical fiber
- Optical fiber directs light into spectrometer



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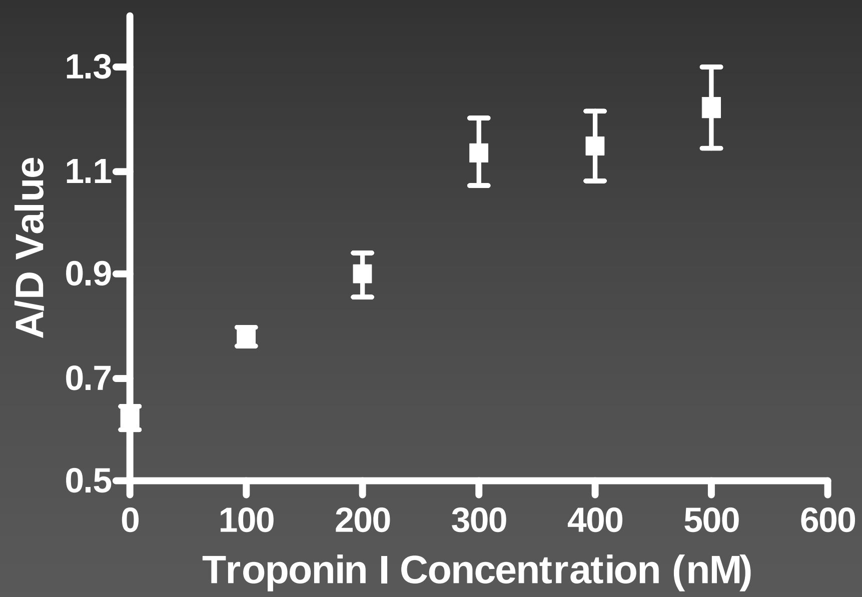
Troponin I Dose Response



- Sensor response measured by acceptor to donor fluorescence peak emission (A/D Value)
- R^2 value: 0.84
- Lower limit of detection: 32.8 nM

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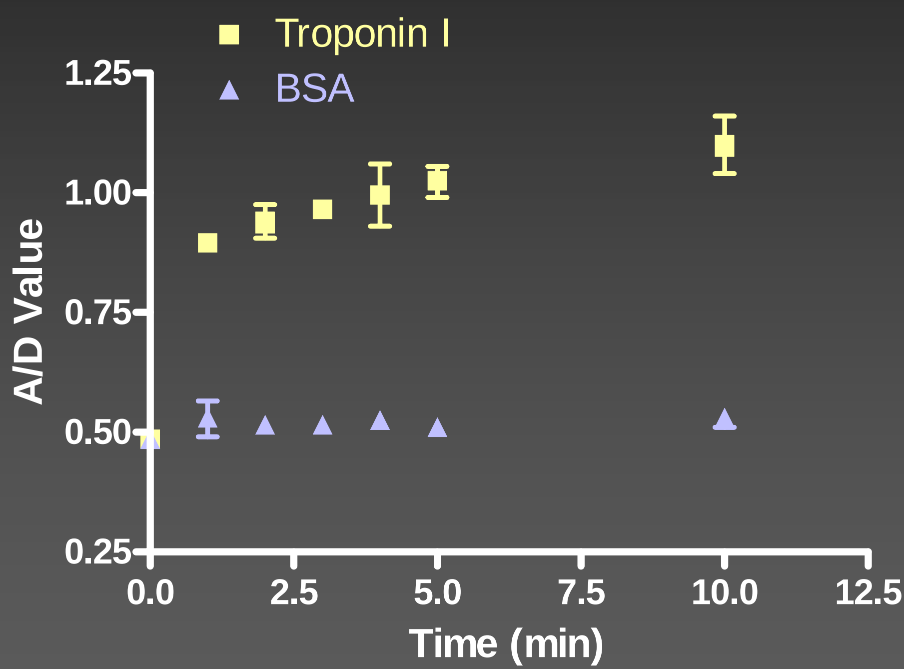
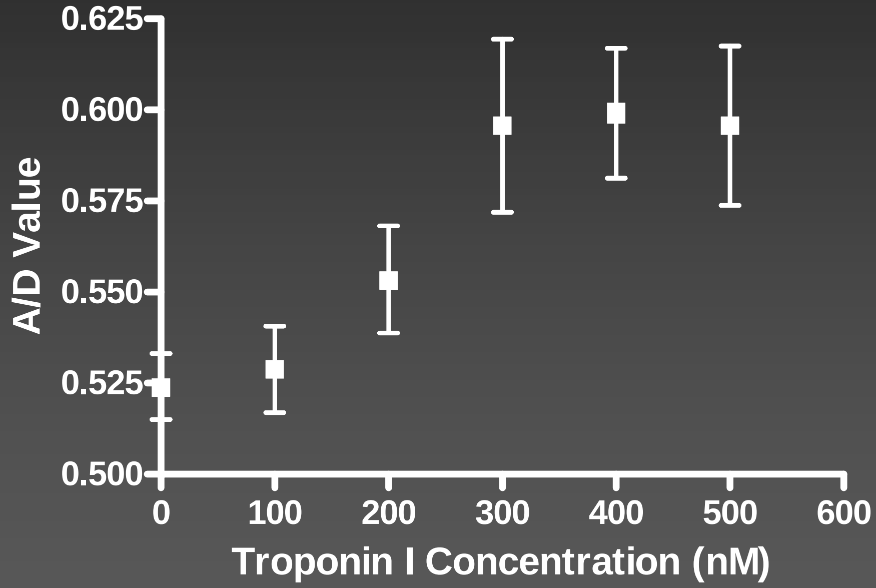
Sensor Specificity and Response Time



- Biosensor response to TnI as compared to Bovine serum albumin (BSA)
  - TnI induces an A/D value increase of 0.611
  - BSA induces an A/D value increase of 0.041
- Largest increase in biosensor response occurs within 1 minute

Sensor Response in Human Plasma



- Sensor dose response repeated with TnI-spiked human plasma
- R^2 value: 0.89
- Lower limit of detection: 55 nM

Discussion

- Biosensor response time (~ 1 min) is currently lower than commercially available assays (> 15 min)
- Sensitivity and detection limit must be further optimized for feasible application
- Immobilization of sensor architecture could potentially enhance sensor by increasing sensitivity and lowering total assay time
- With further development, the proposed optical biosensor could be a viable diagnostic method in the clinical environment

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